the final "exhaustive explosions of abnormal violence," together with the vast sea and air waves, and the subsequent optical phenomena, which accompanied that of Krakatão.

Prof. Judd next deals with the nature of the materials ejected, and draws attention to the different *physical* characters presented by the lavas ejected from Krakatão at different epochs, the final compact lavas of 1883 being porphyritic pitchstone, and obsidian, containing about 70 per cent. of silica, and so nearly identical *chemically* with those of some of the earlier outpourings as to suggest refusion.

The heavier lava dust which fell in Java and was examined by numerous geologists, including Prof. Judd himself, exhibits a peculiarity which he considers to be without precedent, in that it contains almost every variety of feldspar crystals. The base in which these crystals was found to be embedded presents great differences in its fusibility, the pitchstone melting with great difficulty, and the obsidian with ease. This latter point, in combination with other circumstances, leads Prof. Judd to one of the most important of his conclusions, viz. as to how eruptions come to differ not merely in magnitude but in quality: for example, how a volcano such as Krakatão at one time emits massive and viscous lava-streams as it did in former times; at another, pours forth a more liquid lava; and again, as on this occasion, bursts out with explosive violence into an eruption in which most of the lava is converted into pumice. He considers that the older lavas have been *chemically* acted on by water which has slowly percolated through the crust in the vicinity, and that the new compounds thus produced are not only more readily fusible, but more easily convertible into pumice. Volcanic action is thus concluded to be brought about not directly by the physical action of externally derived water, but by changes in the physical properties of rocks chemically altered through the medium of such water.

In connection with the optical effects which were witnessed subsequent to the eruption, and which are found to be connected chiefly with the finer solid ejecta, Prof. Judd finds evidence, both from a study of the Krakatão pumice as well as the finer dust which fell at great distances, that by the unusual violence of the explosions during the major outburst a large quantity of the very finest threads and dust of volcanic glass was thrown out into the higher atmospheric regions, where it might remain suspended for very long periods. He also points out that the absence of any sign of materials characteristic of Krakatão in the rainfall of distant places is no evidence against their wide diffusion, since the most characteristic substance in the Krakatão dusts was rhombic pyroxene, and this by reason of "its high specific gravity and its slight friability would be among the first to fall."

Prof. Judd brings his section to a close by a general review of the circumstances which have led him to adopt the view already enunciated regarding the cause of volcanic action, viz. that the liquidity of a lava and the violence of an eruption depend on the extent to which the lava has, as it were, been hydrated under the influence of slow aqueous percolation. Lavas of precisely the same composition, and at the same *temperature* may vary greatly in their eruptive action simply by the changes thus effected in their fusion-points. This refined form of the volcanic theory, which is put forward by Prof. Judd, appears to show that the Vesuvian stage of eruption is a paroxysmal form of earth sickness, due to lava gases indirectly generated by water action, while the quiet outpourings both from cones and fissures which have taken place so widely both in the past and present ages, represent the more normal welling up of lava which has been less altered by water action. For this reasonable deduction and the clearer insight afforded into the *modus operandi* of volcanic and seismic phenomena, we are, without doubt, indebted to Krakatão.

(*To be continued.*)

THE BRITISH ASSOCIATION.

SECTION H.[1]

ANTHROPOLOGY.

OPENING ADDRESS BY LIEUTENANT-GENERAL PITT-RIVERS, D.C.L., F.R.S., F.G.S., F.S.A., PRESIDENT OF THE SECTION.

II.

THE accompanying map of Great Britain shows the monuments that I have been the means of obtaining by the consent of their owners.

The Pictish Tower at Mousa in the Shetlands, which is well known to be the best preserved monument of this class in the country, has been included by the owner, Mr. Bruce, and some necessary repairs have been done to it by the Government. In the Orkneys the owners of the scheduled monuments declined to make use of the Act, but they are well looked after. The same applies to the Bass of Inverurie, the Vitrified Fort on the hill of Noath, the Pillar Stones at Newton, in the Garioch, and the British settlement at Harefaulds, in Lauderdale, which latter, however, is in such ruinous condition that the remains of it are scarcely worth preserving. The Suenos Stone near Forres; the Cairns at Clava, on the banks of the Nairn; the Cat-stane at Kirkliston; the Burgh of Clickanim, have also been withheld by their owners, but most of them are very well taken care of. The Cairns at Minnigaff were nearly destroyed before they were scheduled, and are not worth preserving. The inscribed stone in St. Vigean's churchyard is preserved in the porch of the church, but it is not included. On the other hand, Edin's Hall, the largest and most southern of the remains of the Pictish Towers in Berwickshire, has been included by Mr. J. S. Fraser-Tytler; the Black and White Catherthuns have been added by Miss Carnegy Arbuthnot; both these are large camps having ramparts of stones and earthworks round them, and they are described in General Roy's work. The Pictish Towers at Glenelg have been included by Mr. James Bruce Bailey; they are in a very bad state of repair, and have been propped up by the Government. The inscribed stones at Laggangairn, New Luce, have been included by Lord Stair; they are at a great distance from any road or habitation, and the protection afforded them, beyond the powers contained in the Act, must be regarded as nominal. The Peter's stone, on the road from Wigton to Whithorn, has not been added; it is an important stone, and is in a dangerous position; it has already suffered damage, and it is to be hoped it will be included hereafter. The chapel on the Isle of Whithorn, supposed to be that built by St. Ninian, has been included by Mr. R. Johnstone Stewart; this was not in the schedule. The Pillars of Kirkmadrine have been included by Mrs. Ommaney McTaggart; they are the earliest Christian monuments in the country. I suggested that Government should contribute towards building a small chapel to contain them, which has been done. The Cross at Ruthwell, with its remarkable runes, which were gradually being destroyed and covered with lichen, so that its inscription could not be read, has also been added. I suggested that the Government could contribute towards building an annex to the neighbouring church to contain it, which has been done. This was not in the schedule. The cup-marked rock of Drumtrodden, Wigtonshire, has been added by Sir Herbert Maxwell, and Government has granted a certain sum towards building a shed over it. It was not in the schedule, but is a good example of its class. Barsalloch Fort, Wigtonshire, the Moat Hill of Druchtag, the Drumtrodden standing stones, Wigtonshire, have also been added by Sir Herbert Maxwell. St. Ninian's Cave, with its early Christian crosses, has been included by Mr. Johnstone Stewart. In the Island of Lewis the remarkable standing stones in the form of a cross at Callernish, and the Broch at Carloway, have been added by Lady Matheson. This latter is, next to Mousa, the best Pictish tower in the country. In Cumberland, the Stone Circle on Castle Rigg has been put under the Act by Miss Edmondson. In Westmoreland, Arthur's Round Table, an earthen circle with a ditch in the interior, and Mayborough, a large circle with an embankment of stones and the remains of a stone circle within, has been included by Lord Brougham. In Derbyshire, Arborlow, a large circle similar to Arthur's Round Table, with the remains of a stone circle, the stones of which are prostrate, and a large tumulus near it, has been added by the Duke of Rutland. Hob Hurst's House, and the Circle on Eyam Moor, which also has a large cairn close to it, have been included by the Duke of Devonshire, and the Nine Ladies, a circle of small stones on Stanton Moor, by Major Thornhill. In Gloucestershire, Uleybury, a long barrow with a well-preserved stone chamber, has been added by Colonel Kingscote. In Oxfordshire, the Rollrich stones have been included by Mr. J. Reade. In Kent, Kit's Coty House by Mr. Brassey, which is the remains of a long barrow, the traces of which can be seen, with part of the stone chamber remaining. In Somerset, the Stone Circles at Stanton Drew, by Mrs. S. B. Coates, and the Cove there by Mr. Fowler; the chambered tumulus at Stoney Littleton by Lord Hylton. It Wiltshire, the long barrow at West Kennet by the Rev. R. M. Ashe, and Silbury Hill by Sir John Lubbock. In Dorsetshire, the chambered long barrow, called the Grey Mare and Colts, near Gorwell, by Mr. A. B. Sheridan; the circle of Nine Stones near Bridehead Park by Mr. R. Williams; the Stone Circle on Kingston Russell Farm by the Duke of Bedford; and in Wales the Pentre Evan cromlech, one of the largest in the country, by Lord Kensington—

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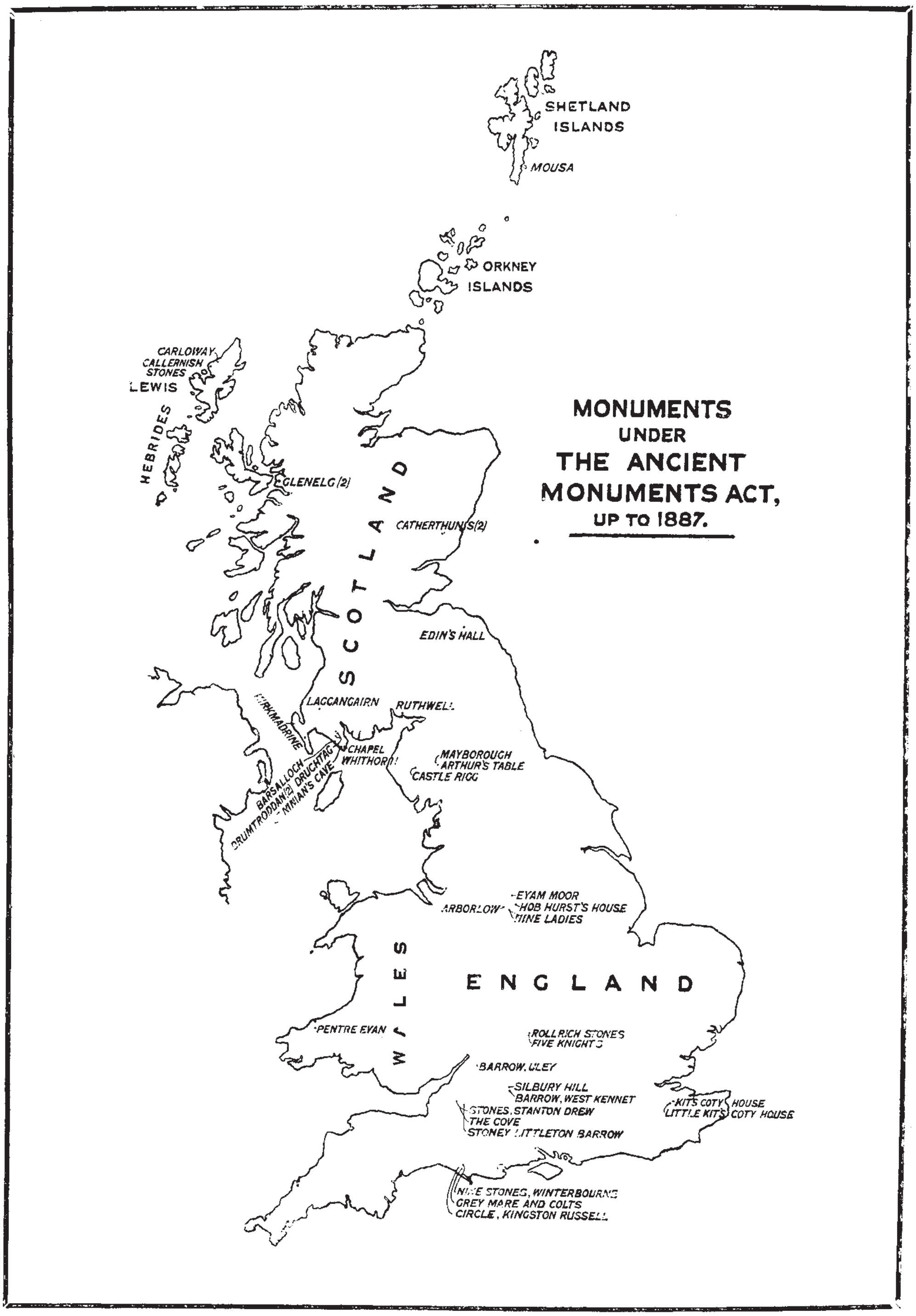
[1] Continued from p. 518.



making in all thirty-six which have been placed under the Act with the consent of their owners. All these and many others have been surveyed; plans, drawings, and sections have been made of them, which are contained in the book now upon the table, which is open for the inspection of the members. I hope to publish these shortly. Besides these monuments which are included under the Act, a good deal of useful work has been done by communicating with the owners of other monuments, without using the Act.

I think it speaks well for the landowners that so many should have been willing to accept the Act, considering that so few of them take much interest in antiquities. There is not a more public-spirited body in the world than the much-abused landowners of England.

Those who have refused have generally done so on the grounds that they wish to remain responsible for their own monuments, and I think I may say, from my own observations, that there is very little damage to prehistoric monuments going on at the present time. Public opinion has done more than any Act of Parliament could do, and it appears to me that it is generally known throughout the country that any wilful damage to the monuments would be universally condemned.

But it is well to consider the operation of the Act, and how it may be improved. The provision which makes it illegal, ever after, to destroy the monuments that are now placed under the Act by their owners, and to enable magistrates to punish offenders summarily, appears to me excellent, and worthy to be retained. But there are defects to which it would be well to give attention. By the present Act, the Government are made responsible for all the monuments that are included, which entails expense; and as members of Parliament generally take very little interest in ancient monuments, and the great object of the Government must always be to curtail expenditure, additions to the list are not as a rule encouraged.

I last year obtained eleven new monuments, but I was told that this was too many, and that some must be omitted, so I selected three of the least important, and they have not been included. This, I think, is objectionable; the two provisions of the Act which I have mentioned should be applied as widely as possible. If the provision making Government responsible for the preservation of the whole of them is altered, there will be no inducement on the part of the authorities to reduce the number to be included. At present local archæologists wash their hands of the matter, thinking that there is a Government Inspector whose business it is to look after the monuments. This is a mistake; the proper function of the Inspector is simply to look after the monuments that are included, and to advise the Commissioners—not to obtain new monuments for the Act. I have done so because I was charged in a special manner with the organization and working of the Act on its first introduction, but it is beyond the proper functions of the Inspector. I have done it as a private individual who takes an interest in the subject, and any other private individual may do the same. Moreover, it is impossible for an Inspector to stand sentry over all the monuments that are put under the Act. The police are requested to look after them as well as they can, but damage must occasionally be done which local archæologists are in a better position to ascertain and to remedy, using the provisions of the Act for the purpose.

It may be that my position as a landowner, as Lord Stalbridge said in his letter asking me to take the appointment, may have had some effect in enabling me to persuade some of the other landowners, but you cannot insure always having a landowner for an Inspector, and it is desirable now to put the Act on a working footing. It is much to be wished that local Archæological Societies should be made to feel themselves responsible both for the inclusion of monuments under the Act, and their preservation afterwards; the Act arms them with full powers for the purpose if they think proper to use it.

At present no Archæological Society has rendered any assistance whatever, but Sir Herbert Maxwell, in Galloway, has not only offered his own monuments, he has persuaded his neighbours to do the same. What Sir Herbert Maxwell can do, others equally public-spirited can do also, if it is clearly understood that it rests with them to take action in the matter, and I think it should rest with them, because, being local, they can do more than a single Inspector charged with the supervision of the whole of the monuments of Great Britain. I think that the Government should continue to appropriate a small sum (it is now under £200 a year) to apply to such purposes as may be thought desirable, such as building sheds to preserve the monuments, but that they should not necessarily be held responsible for all the monuments placed under the Act, and that, the Bill being a permissive one, it should rest with the public to make use of it or not, as they may think proper. If there is no demand for the preservation of monuments, there is no reason why the country should be saddled with the expense of it. If there is a demand, let those who are interested use the law on the subject as they use any other to prosecute delinquents. I think, also, the provision that the new monuments before being included should rest forty days before Parliament might be advantageously abolished. The First Commissioner, with the practical knowledge of the Inspector, is fully competent to decide upon the monuments to be included. It is evident that, if it were desired to save any monument that might be threatened, the forty days would afford ample time to enable the destruction to be carried out before the Act could be applied. With these alterations I think the Act would take root in the country and produce better results. Of one thing, however, I feel certain: that, as long as the owner of a monument takes an interest in it, he is the best person that the public can look to for the preservation of it.

In conclusion it may perhaps interest the meeting if I say a few words upon the results of my recent excavations on the borders of Dorset and Wilts, upon which I have been at work for the last eight years, the detailed account of which is recorded in the two quarto volumes extending to 541 pages and 159 plates, the last of which is just completed.

I have excavated numerous barrows of the Bronze Age near Rushmore, about half-way between Salisbury and Blandford. Winkelbury Camp has been examined and sections cut through the ramparts; an Anglo-Saxon cemetery near it has been dug out, and two Romano-British villages thoroughly explored, the positions of which are shown on the map now exhibited on the walls, a reduced facsimile of which is given on p. 545.

In recording these excavations I have acted on the principle that views upon anthropological subjects are constantly on the change, as our imperfect knowledge of the early inhabitants of the country increases, and that when the records of excavations are confined to opinions and results, it is probable that those facts only which coincide with the theories current at the time receive the prominence they deserve.

The requirements of the future demand that everything should be recorded and tabulated in such a way as to be of easy access hereafter. I have therefore established a system of relic tables in which, without confusing the text and making it unreadable, every object, however small and apparently trivial, is inserted, and the great majority of them are figured in the plates.

It would occupy too much time to enter into details on the present occasion. The result has been to show by a computation from the bones of twenty-eight individuals, found buried in pits in the villages, that the Romanized Britons of this district were an exceedingly small race, having an average stature of not more than 5 feet 2·6 inches for the males, and 4 feet 10·9 inches for the females; that the tallest man was only 5 feet 7·8 inches, and he was an inch and a half taller than the next tallest man.

In head form, the great majority of twenty-six skeletons measured were mesaticephalic and mostly coffin-shaped, but three were hyper-dolichocephalic and two brachycephalic, which shows that the head form approached that of the Neolithic, long-barrow people, with a probable admixture of either Roman or Bronze Age types.

The stature is slightly less than that given by Thurnam for the long-barrow people of this district, but Dr. Garson informs me that, in a paper which he will read at this meeting, he will show that the height of the Romano-Britains whom I have discovered tallies as nearly as possible with that of some long-barrow bones found near Devizes. All are, of course, shorter than the skeletons of the Bronze Age, two of which I have found in the same locality, and which are of the usual tall stature and round-headed types of that people.

The Romano-Britons are also considerably shorter than the skeletons of the Anglo-Saxons found in the cemetery at Winkelbury, which are described in my second volume.

The problem, therefore, with respect to these Romanized Britons appears to be this: Are they the descendants of the long-barrow people, and do they owe their small stature to that circumstance, or is their small size to be attributed to their largest men having been drafted away into the Roman legions abroad?

Prof. Rolleston examined a number of skeletons from a cemetery at Frilford, which he believed to be Romanized Britons, and found that they were of large size, but in my address to the Royal Archæological Institute at Salisbury, last year, I expressed some doubt about the period of these skeletons, and in a paper since published by Dr. Beddoe I see that he rejects the evidence of their being Romano-Britons upon the same ground that I had doubted it, and he quotes Barnard Davies and Thurnam for the occurrence of other skeletons of these people of the same or nearly the same stature as those of the villages that I have explored.

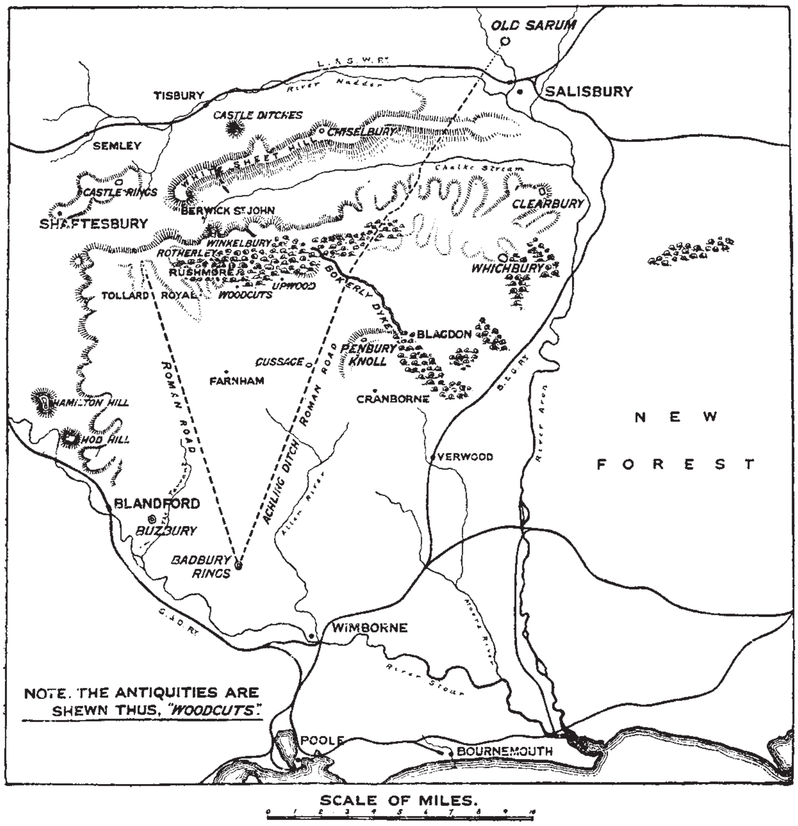
We are therefore evidently beginning to accumulate reliable information about these people, whose physical peculiarities are less known to us than any other prehistoric, or rather non-historic, race that has contributed to the population of this country.

Thurnam shewed that the large-sized, round-headed Belgæ probably penetrated no further westward than the borders of the district I am speaking of, and that the bowl barrows and the long barrows of the Stone Age predominated to the westward of it.

Since the present volume of my excavations was in print, I have quite recently made another discovery of considerable interest bearing upon this question.

Bokerley Dyke is an ancient intrenchment which cuts across the old Roman road from Old Sarum to Badbury Rings. It is an earthwork of considerable magnitude, with a ditch on the north-east side of it. It appears to have originally occupied all the open downland spaces intervening between the ancient woods, which latter probably, by means of felled trees, afforded sufficient defence without earthworks. It extends with its dependencies and detached prolongations more or less all the way from White Sheet Hill, on the north-west, to Blagdon Hill, on the south-east, a distance of about nine miles. Its origin and use have been frequently discussed by archæologists, but no one has hitherto assigned a right date to it. I have now cut two broad sections through it on either side of the Roman road, models of which are exhibited, with the result of proving that it is late Roman, or post-Roman, and is of the same date as the villages; Roman coins, to the amount of 500, of late date, extending to Constantinus and Gratianus, and pottery, having been found in both sections, all through the rampart, down to the old surface line. It appears that the dyke had been cut through ground occupied at an earlier date by the Romanized Britons, and that in forming the ditch they threw up the refuse from the habitations to form the bank, including the scattered coins and pottery. A human skeleton of similar character to those found in the villages was also discovered beneath the old surface line in one of the sections, the old surface line being clearly marked over it, showing that it had been buried there before the rampart was thrown over it. From this it appears probable that this dyke was thrown up to defend the Romano-British villages that are situated to the westward or rear of it, from an attack from the east, and that this must in all probability have been done at the time when the Saxon invaders were pressing upon them from the eastward.

MAP SHEWING THE AREA FORMERLY OCCUPIED BY CRANBORNE CHASE, WITH THE ANTIQUITIES CONTAINED IN IT.



This discovery throws a flood of light upon the history of this part of the country at that time, and shows that the Britons must have made a stout defence against their Anglo-Saxon conquerors, sufficient perhaps to account for the apparent predominance of British blood which has been noticed amongst the existing population of the district.

Wansdyke, which runs from a spot not far to the north of the Bokerley Dyke in the direction of Bath, has the same defensive attitude as Bokerley, and the examination of it, which it is proposed to make, will show whether or not it is of the same period.

The observations of Dr. Beddoe and other physical anthropologists upon the present population of the country show that the people of the South-West of England are, as a rule, shorter and darker than those to the eastward, and my own observations upon the people of this particular district will, when they are systematized, tend to define the area of this ethnical frontier more precisely. It would be a remarkable result if it should hereafter be shown that the physical changes observable in the distribution of the existing population are in any way coincident with these lines of defensive earthworks of the Roman or post-Roman age: and if it should be further shown that the same physical characteristics have persistently belonged to the people of this region ever since the time of the Neolithic folk of the long barrows, we shall find ourselves in the presence of anthropological deductions of some value in their bearing on the history of England. I purposely avoid speaking with confidence upon this point, feeling certain that the necessary evidence for deciding the question lies buried in the soil of the district, and will hereafter be unearthed. I shall resume the inquiry as soon as the harvest, if such it can be called this year, is over; but without bias, and with a mind prepared to throw over any preconceived hypothesis the moment it shows itself to be untenable.

SECTION A—MATHEMATICAL AND PHYSICAL SCIENCE.

Members of the Mathematical and the Mechanical Section had a meeting in the rooms of Section A for the special purpose of discussing the question of lightning-conductors. The chair was occupied by Prof. G. F. Fitzgerald, President of the Mathematical and Physical Science Section.

Mr. W. H. Preece, President of the Mechanical Section, opened the discussion, and said that if we wanted to know anything about atmospherical electricity, we had to go back to the works of Benjamin Franklin, 100 years ago. Up to 1870 there were absolutely no rules for the guidance of those who desired to erect lightning-conductors for the protection of buildings. In that year a great Conference was held on the subject, and the result of its deliberations was published in a book, and included a set of rules for the construction of conductors. We had since had great experience of them. He had under his supervision no fewer than 500,000 lightning-conductors. Some time ago a lectureship on atmospheric electricity was founded in memory of Dr. Mann, who experimented on the protection of buildings in South Africa. Prof. Oliver J. Lodge was selected as the lecturer, but, instead of cracking up the work of the Conference, he took the other line, and, if his statements were true, lightning-conductors would be of no use, and no buildings would be safe in a thunderstorm. Prof. Lodge had committed himself to fallacies which it was now his duty to bring before the meeting. The Professor assumed that a lightning-rod formed part of the flash. Well, it did not. Nobody had ever seen a flash of lightning strike a conductor. The function of a conductor was to prevent the possibility of the building being struck by the flash. If it should be struck, there was some defect in the construction of the conductor. Lightning did not go careering wildly about, but passed along a path prepared for it. There was another fallacy, viz. that a flash of lightning was instantaneous. There was no proof of that. We saw a flash of light, which indicated the path of the discharge, but how long the discharge lasted we did not know. There were invisible flashes of lightning, which was proved by the fact that persons had been killed under trees when there was no visible flash. He, however, came to that conclusion from the effect on telegraph-wires, where there were currents of sensible duration, showing that the flash was not instantaneous. The next part was the hardest to discuss. It was the assertion that lightning was oscillatory in its character; that it did not go direct from the cloud to the earth, but went flashing backwards and forwards with considerable frequency. This assertion was based more on mathematical reason than on absolute observation, and engineers had no great respect for mathematical development unless it were confirmed by absolute experiment. The facts against the theory were that electro-magnets were affected for a considerable duration of time by lightning-flashes. Iron and steel were affected, and he had heard letters of the alphabet signalled along the telegraph-wires by a flash—the letter R which needed three signs, C which needed four, and there was a case on record of G, which needed eight signs. Under those circumstances the flash could not be oscillatory unless the oscillations were very infrequent. A discharge from condensers or Leyden jars might be oscillatory, but they were dealing with flashes of lightning. While he was attacking Prof. Lodge in that way, he must say that no one had worked harder or more honestly in the matter. Prof. Lodge had made experiments, and they were correct, from which he deduced that the self-induction of copper was greater than that of iron. He also had repeated these experiments, but his deductions were just the opposite. There was no doubt the Professor was on the brink of a discovery. He had started a fresh hare, which electricians must follow up and kill. Self-induction was called up to explain all the phenomena which they did not understand, and he inclined to think it was very much what the Americans called a bug. In the telegraph science they had known it for many years, and called it electro-magnetic inertia. The next fallacy was that most conductors did not protect any area, but it was known from evidence that they did. He preferred to stand upon the experience of the past rather than upon Prof. Lodge's mathematical assumptions. There was a tendency to hasty generalization among mathematicians, but there could be no doubt that the experiments of Prof. Lodge and others were opening their minds to the true nature of electricity, and that they would in time be able to speak of the mechanical character of electricity. They wanted to know where the energy came from which was so destructive in a flash of lightning. Aqueous vapour condensed and falling as rain at the rate of 1 millimetre per acre per hour developed an energy of 600 horse-power per acre. There was the creation of the energy which only wanted further development to turn into a source of electrical energy. He felt convinced that the result of that discussion would be to establish the truth of the position taken up by the Lightning-Rod Conference, and would bring to the front what they were all anxious to see, the true theory of electricity shadowed forth by Prof. Fitzgerald in his opening address, and that would make this meeting an epoch in the history of electricity.

Prof. Oliver J. Lodge said he had no lightning-conductors under his supervision, and all his conclusions were formed from experiments, and if they were correct very few buildings were effectively and thoroughly protected at the present time; and, further, if his views were correct, lightning-rods would in the future cost very much less than now. The term electro-magnetic inertia seemed to imply that they knew more than they did, so he preferred self-induction until they attained to knowledge. Mr. Preece said that no properly-constructed rod ever failed, but in the report to the Conference there were a number of entire failures named. He had made some very careful experiments in which he provided alternative courses for an electric current, and he found that it required less electromotive force to send the current along a thin iron wire than along a thick copper one. According to Mr. Preece, the object of the conductor was to prevent a flash of lightning, but rods were struck and melted. The conductor had two functions to perform—to act as a point and prevent a flash if it could, and to carry off a flash when it could not help receiving one. The electric charge had some energy, and they could not hocus-pocus it out of existence. It might be better to let it dribble away slowly down a bad conductor than to let it rush headlong down a good one. The length of flash was a question for the consideration of meteorologists, and the duration of flashes was a point on which the same gentlemen might do good work. He had seen flashes which appeared to last two or three seconds, but he thought they must have been a succession of flashes. The fact that flashes deflected the compass-needle did not prove that they were not oscillatory, nor did it prove anything as to their duration. A momentary flash might produce the same effects. There was the question of a flash magnetizing a bar of steel. An oscillating current was able to do that; although Prof. Ewing used an oscillating current to demagnetize steel. The discharge of a Leyden jar caused an oscillating current. The charging was like lifting a pendulum rod suspended freely at one end. When the jar was discharged it was like releasing the pendulum; it must oscillate, and so must the electricity, and its oscillation would vary in accordance with the friction and other modifying causes. The greater the electro-magnetic inertia, the more certainly would there be oscillation. With regard to the protection of areas, the area which Mr. Preece imagined as protected was so small that they might give it him without discussion. There was, however, in his opinion no sure area of protection. Mr. Preece might have pressed him hard on the question of the conditions of a flash. He (the speaker) had assumed that the flash behaved as electricity did in an experiment. The cloud, however, was not like the tinfoil of a Leyden jar; it was made up of globules with spaces between them, and a discharge might be more like that of a spangled jar, or might be dribbled away a bit at a time, and not by great rushes. But they could not assume that it would always do so, and must prepare for the occurrence of a great rush. The true character of lightning must be discovered by observing lightning, and not by experiments in a laboratory. The spark of one induction-coil at a considerable distance would start another one sparking merely by its light. From that he came to the conclusion that when there was a very bright flash of lightning, it must involve very important consequences. There was no doubt that it would cause discharges all over the neighbouring area, and so he would say that areas of protection were misleading, and if a flash had that effect, they had better be without it if possible.

The Hon. Ralph Abercromby, who showed a number of photographs of lightning flashes, said there was no absolute evidence in the photographs of flashes of lightning following each other rapidly on exactly the same path. There was, however, distinct evidence of the tendency of lightning-flashes to occur parallel to each other. There seemed to be a tendency in lightning flashes to be ramified, to give off threads all round the main flash. Photography gave conclusive evidence that flashes were not so instantaneous as was generally supposed. It showed that the flash did not always jump from a cloud straight to the earth, but sometimes went meandering through the air and tying itself into knots, so that it could not be so instantaneous as was imagined. He was of opinion that lightning-clouds were generally more than 500 feet high, but lightning was rarely much higher than 10,000 feet high. By this he did not mean that lightning might jump 10,000 feet from the cloud to the earth; but that at an altitude of 10,000 feet on a mountain-side a thunderstorm was usually *below* the observer.

Lord Rayleigh said that, although some mathematicians were unpractical, yet it was to mathematics one must go to find the results of known causes under new circumstances. He had no special knowledge of lightning-conductors, but from his general acquaintance with electricity he should say that Prof. Lodge's experiments could hardly fail to have a most important practical application to lightning-conductors in the future. Mr. Preece spoke of the development of energy by the condensation of vapour into water, but the question was to find how some of that energy came to take the electrical form.

Sir W. Thomson said that mathematicians never predicted that the Atlantic cable could not be laid, but a celebrated engineer did so. He thought Prof. Lodge was in the American stage of inertia and Mr. Preece in the English stage. He believed that if Prof. Lodge proceeded with his experiments he would confirm his discovery that iron wire was a better conductor than copper. Self-induction was in the air, and they were talking of nothing else. He thought Mr. Abercromby's idea as to the duration was correct. It seemed to him probable that it was the sound of one spark which caused another rather than the light. There was the photograph giving three parallel flashes. It would be well if some experiments could be made to discover whether flashes occurring like that were simultaneous or followed one another, being started by the light or sound vibrations of the first. It was rather startling to find that a lightning-rod had protecting power over so small an area, and he would like to ask Mr. Preece whether copper had been experimentally proved to be better than iron. They could come to one conclusion from what they heard—namely, that houses made of sheet iron would be the safest possible places in a thunderstorm. The question of the effect of self-induction on statical discharges was a very important one. He suggested as a class experiment the discharge of a Leyden jar through a number of students (1) when they were arranged in zigzag rows, so as to have no self-induction in the path of the discharge; and (2) when they stood in a circle, so that the self-induction of the path was a maximum. The students should stand on insulating material. He thought the result of such an experiment would be to show that the students in the middle of the chain would feel the effect of the discharge far less in the second instance than in the first. With reference to the reports as to the occurrence of globular lightning, he believed them to be much exaggerated, and expressed an opinion that the whole effect might be a physiological optical delusion. Reiss experimented some forty years ago on the question of magnetism by jar discharges, and found that the direction of superficial magnetization sometimes was the one to be expected, sometimes the opposite one. He suggested new experiments as to the influence of the rate of oscillation on the result. The most efficient protection for gunpowder against lightning would be, he thought, to put it in a house whose exterior was entirely of iron and to put no lightning-rod on it.

Prof. Rowland observed that the conditions of Prof. Lodge's experiments were scarcely the same as those of actual lightning, and he pointed out that the length of the spark was no measure of the resistance of the conductor. Further, he showed some effects in Mr. Abercromby's photographs which were probably due to the astigmatism in the lens of the camera.

M. de Fonvielle, who spoke in French, observed that Sir William Thomson had said most eloquently that Mr. Preece was taking the English side of the question and Mr. Lodge the American side, but he must say that Sir William Thomson himself had taken the French side, and he had proposed a revolutionary system which consisted in the building of iron houses. He took the liberty, though being a Frenchman, to disagree with the great electrician, and to stand with Mr. Preece as an English conservative, with reference to lightning-conductors. Lord Rayleigh said that mathematicians and physicists should unite together, but he supposed that Lord Rayleigh would agree with him in remarking that Mr. Preece was realizing that alliance in a very remarkable manner, for on the one hand he dealt with a large number of experiments and observations of natural facts, and on the other hand he introduced statistics, or rather the calculation of probabilities, which was one of the highest branches of mathematics. The experiments made in laboratories were different from those which were presented by Nature only so far as they were conducted on very widely different scales. On the previous day, in that hall, M. Janssen had proved by his observations on the action of oxygen on the composition of the electric light that in many phenomena there was a coefficient behind. He congratulated them on the aid they were now receiving from photography. He should advise the meeting to delay its opinion for the time until the completion in Paris of the Eiffel Tower, which would be the most extraordinary lightning-conductor in existence, being 1000 feet high. He must, moreover, state that Paris was practically free from calamities produced by lightning. They had erected a sufficient number of lightning-rods, according to the principles so admirably advocated by Mr. Preece, and that was a strong evidence that Mr. Preece was altogether travelling in the right direction, quite irrespective of any mathematical or physical demonstration.

Prof. George Forbes said that Mr. Preece did not mean to say that mathematicians came to wrong conclusions when they had all the right data, but that they sometimes came to a conclusion without taking all the data into consideration. Prof. Lodge had come to say that if iron was not better than copper, it was at least as good; but they could not be quite prepared to accept that, because the experiments might be tried in instances more nearly approaching the natural conditions, and in that case it was quite possible that copper would be found to be the best.

Sir J. Douglass said that his experience of lighthouses protected by lightning-rods covered a space of forty years, and was comforting to the members of the Lightning-Rod Committee. He never knew a rod fulfilling the conditions he prescribed to fail in protecting the lighthouse and adjoining buildings.

Mr. J. Brown suggested the use of a revolving camera in taking photographs, in order to separate flashes, and thus see if each is single or not.

Mr. Sidney Walker said that anything which would cheapen lightning-conductors would be gladly welcomed. In the cases where damage had occurred, he believed that the result was due to a defect in the conductor. He pointed out that iron would not stand the weather so well as copper, and that, besides, it would be affected by the gases at the top of a factory or similar place.

Mr. G. J. Symons said he had investigated every accident by lightning of which he could hear, and had so got valuable experience. The conclusion left on his mind was that if people would erect conductors precisely in accordance with the rules laid down by the Conference,[1] and fulfilling all the conditions, they would be absolutely safe. Where accidents occurred to buildings with conductors, there was a reasonable explanation to be found. Prof. Lodge's experiments were laboratory experiments, and to get the real facts they must have something on a much larger scale, perhaps by a series of interrupted conductors on posts on the tops of some of those high hills where storms frequently occurred. With regard to protected areas, there were only two cases on record, and those doubtful, of anything being struck within a protected area.

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[1] Report of the Lightning-Rod Conference (Spon, 1882).

Dr. Walker said he saw an obelisk on top of a hill struck. The top was knocked off, and the fluid came from the steps of the monument at fourteen different points, ploughing up the ground, and breaking rock at 100 feet distance.

Mr. Wood thought the black flash shown in one of the photographs was due to the reflection of one of the other flashes.

Lord Rayleigh said Stokes attributed that to the combination of gases in the path of the flash causing an opaque stratum.

Prof. Lodge said he could not understand why a conductor should have such a good earth. Why did not three points do at the bottom as well as at the top? If properly constructed conductors never failed, how was it that the hotel at Brussels was burnt, for that was considered protected in the most orthodox way? He would not say that conductors were of no use; they were of great use, but not absolutely certain. In his experiment he was bound to adopt the plan he did, because the experiments could not be done in any other way. It was only the outer surface of the conductor which conducted, and there was no particular good in the centre of a rod. A tube would do as well, and would be all the better if opened out into a flat bar, and yet better than that would be a strand of wires. Iron buildings, to be safe, must have perfect connections, for the smallest gap might give off a spark. That was the danger in houses supplied with gas; if the fluid travelled along the pipes and came to a gap, a spark and a fire might result.

Mr. Preece said the points between Prof. Lodge and himself were reduced to a very small compass indeed. He himself had always been a great advocate of iron on account of its cheapness. The use of copper caused needless expense in the erection of lightning-conductors. He believed every private house could be protected in accordance with the recommendations of the Conference for £1, if people would buy a coil of stranded iron wire a quarter of an inch in diameter, with the finial points, and have that put up.

The President summed up the discussion, and said the principal thing for them to pay attention to was that prevention was better than cure. There could be very little doubt that the presence of a considerable number of conductors afforded a great deal of protection to the area in which it existed, as was shown in the instance of Paris. It was desirable, if possible, that the whole country should be covered with conductors to prevent the discharge of flashes. There was no doubt that, though there might be room for improvement in the conductors, they had on the whole been right.

THE INTERNATIONAL GEOLOGICAL CONGRESS.[1]

II.

In order to understand the present status of the Congress, and to forecast its probable future, we must briefly note the work done at the two preceding meetings, and compare that with the general results of the meeting just closed. At Bologna the greater part of the time was occupied with discussions upon the exact meanings to be attached to various geological terms, and upon the general principles which should guide us in geological classification. Certain rules were then laid down, which probably few authors have consistently followed, and which it is unlikely will be universally adopted. At Berlin the discussions turned more upon precise questions of classification, especially those relating to the sedimentary rocks; upon the lines by which various groups of strata should be marked off; and, in some cases, upon the names by which these groups should be known. This change of procedure was necessitated by the progress made with the international geological map of Europe; the material for such discussion on classification having been provided in the shape of Reports from various national Committees, of which that from England, presented by Prof. Hughes, was by far the most complete.

At the London meeting the classification of the Cambrian and Silurian strata was fully discussed; and two other questions, only lightly touched upon before, were here considered in some detail—the nature and origin of the crystalline schists, and the upper limit of the Tertiary system.

In Bologna numerous votes were taken, in Berlin several, but in London none The English geologists were in a majority sufficiently large to carry any point upon which they were fairly well agreed, but no attempt was made to test this; and Prof. de Lapparent, in presenting a Report from the Committee appointed by the Council to consider the question of voting, paid a generous tribute to the English members for their self-restraint. There can be no doubt that the adoption of this Report marks an important epoch in the history of the Congress, and that resolutions hereafter voted will carry more weight than those which at present stand on its records. It recommended that members of the country in which the Congress meets should vote separately from the foreign geologists: if the votes of the two groups agree, the question will be taken as settled; if they disagree, the further consideration of the question will be postponed. The resolution further recommended that votes should not be taken on questions which are purely theoretical—such questions to be simply discussed, and various views obtained; and that decisions of the Congress should only refer to the more practical questions.

Two Commissions of the Congress have existed since the Bologna meeting—that on the Map of Europe, and that on Nomenclature and Classification. The work of the former is plainly marked out, and much has yet to be done. The other Commission has, however, in many respects served its purpose; it has obtained Reports from the various national Committees, most of which have been ably summarized by Prof. Dewalque. The future work of the Congress will partly lie in discussing these Reports, and in deciding such questions in general classification as may apply to wide districts, leaving minor points to be worked out by each country for itself. A Commission was therefore appointed with altered and somewhat wider powers; its functions will more fully shape themselves at the Congress in Philadelphia. As the future progress of the Geological Congress lies so much in the hands of this Commission, it may be desirable to record here the names of its members, which are to some extent the same as those already given (p. 519) for the Council of the London meeting, but there are some additions and changes:—Germany, Zittel; Australia, Liversidge; Austria, Neumayr; Belgium, Dewalque; Bulgaria, Zlatoski; Canada, R. Bell; Denmark, Johnstrup; Spain, Vilanova; United States, Hall; France, de Lapparent; Great Britain, Hughes; Hungary, Szabó; India, Blanford; Italy, Capellini; Mexico, Castillo; Norway, Kjerulf; Netherlands, Calker; Portugal, Delgado; Argentine Republic, Brackenbusch; Roumania, Stefanescu; Russia, Inostranzeff; Sweden, Torell; Switzerland, Renevier. Prof. Capellini was elected President of the Commission; and Prof. Dewalque, Secretary.

The Report upon the Map of Europe was presented to the Congress by Dr. W. Hauchecorne. This stated the progress which is being made. Four or five sheets of Central Europe will be ready for publication during the next two years, and it has been decided to publish the sheets as completed, each with its own title and index, instead of waiting for the completion of the whole of Europe, as was at first intended. A proof sheet (C iv.), containing a large part of Northern Germany, was exhibited; on this there are twenty-four different tints for the sedimentary formations, three for the Archæan, and nine for the eruptive rocks. The map is on the scale of 1 : 1,500,000, and will consist of forty-nine sheets. One colour is taken for each great group—Cretaceous, green; Jurassic, blue; &c. The subdivisions are shown by various modifications of these colours. As a rule, the lower subdivisions are shown by the darker tints, so that the map may be read with more facility than is usually the case with geo-

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[1] Continued from p. 526.